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Fuel treatments in mixed-pine forests in the Great Lakes Region: A comprehensive guide to planning and implementation

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I. ABSTRACT

Fuel management decisions are made within a larger context of resource management characterized by multiple objectives including ecosystem restoration, wildlife management, commodity production (from timber to less traditional forest products), and provision of recreation opportunities and amenity values. Implementation of fuel treatments is strongly influenced by their perceived influence on and compatibility with overarching management objectives. In some cases these objectives may be complementary while in others they may involve difficult tradeoffs. Such tradeoffs are only further complicated by institutional mandates, limited availability of information, and complex ownership patterns. Like natural resource managers across the U.S., those in the Great Lakes Region must balance these competing demands as they seek to build their management programs. However, there is limited information available to support these management decisions in the mixed red (*Pinus resinosa* Ait.) and eastern white pine (*P. strobus* L.) forests of the Northern Lake States compared to other fire-dependent ecosystems.

This project was designed to help fill this gap by completing a review of existing research and, working with practitioners from across the region, developing a decision-aiding tool relevant to the local management context. Specific deliverables include a written summary of knowledge on fuel treatment practices in mixed-pine forests and a computer based decision-aiding tool that allows users to weight objectives according to their own management goals and calculate the expected utility of alternative fuels treatment options.

II. BACKGROUND AND PURPOSE

Several recent federal initiatives (e.g., the National Fire Plan, Ten Year Comprehensive Strategy, Healthy Forests Restoration Act) have focused on fire and fuels management. Two main themes run through these initiatives: 1) they emphasize the use of fuel treatments, such as prescribed fire and thinning, to proactively manage vegetative conditions and reduce the risk of fire, and 2) they recognize the complexity of fuels management and call for natural resource agencies to work across management boundaries and collaborate with the general public.

Throughout much of the previous century federal fire policy was directed at excluding fire from the landscape. In recent years, resource managers and scientists have increasingly recognized the complex and often beneficial role that fire plays in forest and rangeland ecosystems. In many locations, fire exclusion has resulted in ecological changes, such as shifting species compositions, increasing plant density, and declining ecological health (e.g., Langston 1995, Agee 1997, Drobyshev et al. 2008a). The landscape of the northern portions of the U.S. Lake States (Minnesota, Wisconsin, Michigan) has undergone substantial changes since EuroAmerican settlement. Changes to the fire regime brought about by EuroAmerican settlement have had cascading effects through the ecosystems, including habitat patterns for wildlife, nutrient cycles, water flows, forest composition and structure, and terrestrial and aquatic species diversity (Foley et al. 2005; Schulte 2007; Drobyshev 2008a). Logging practices and reduced fire activity have resulted in a decline in compositional diversity, structural complexity, and age variability, resulting in an overall homogenization of red pine (*Pinus resinosa* Ait.) -dominated

forests (Frelich and Lorimer 1991; Frelich 1995). Historically, red pine was dominant across the region, as it is one of the few fire resistant tree species in the eastern United States (Starker 1934). As the extent of naturally regenerated red pine stands have decreased, more fire sensitive species have expanded throughout the area (Cleland et al., 2004; Drobyshev et al. 2008b). A major result of decreased fire activity has been the accumulation of fuels, leading to a greater risk of large-scale fire (Drobyshev et al. 2008a).

At the same time, management goals and objectives are further complicated by social, political, and economic factors. Several agencies, including the USDA Forest Service (USFS), USDI Fish and Wildlife Service (USFWS) and USDI National Park Service (NPS), state departments of natural resources, tribal organizations and non-governmental organizations such as The Nature Conservancy (TNC), manage land within the area according to sometimes differing institutional mandates and management objectives. In addition, much of the landscape contains fragmented ownership patterns with public and private lands intermixed. This fragmentation contributes to the intertwining of management actions and nearby community interests. While such patterns have long posed a challenge for management, they have created increasingly difficult problems in recent years as the population living in the Wildland Urban Interface (where human development meets or intermixes with wildland vegetation) has increased substantially (Radeloff et al. 2005). This increased population has resulted in greater scrutiny of fuels management activities and can influence the selection of management techniques (Shindler et al. 2009).

A growing body of research evaluating public opinion about the use of fuels management approaches has led to several important findings. Decades of research demonstrate that citizens with higher fire-related knowledge are more supportive of fuel management activities such as prescribed fire and thinning programs (e.g., Stankey 1976, Carpenter et al. 1986, Shindler and Toman 2003). Moreover, overall public understanding and acceptance of fuel treatments has steadily increased over the past decades. Early studies found that citizens generally overestimated the negative impacts of fire; not surprisingly, a majority preferred complete fire suppression (Stankey 1976). However over the last several years, an increasing number of citizens recognize the role of fire in the landscape (Loomis et al. 2001, Shindler and Brunson 2003). Studies within the region have also demonstrated a relationship between public acceptance and citizen understanding of the rationale behind and expected outcomes from fuels treatments (Shindler et al. 2009). In addition to citizen knowledge, findings across several locations indicate that acceptance of fuels treatments hinges on: 1) trust in agencies and confidence in local managers to effectively implement treatments (as the treatments themselves carry their own risks and uncertainties); 2) the degree to which citizens have an opportunity to participate in fire planning; 3) citizen beliefs about the outcomes likely to result from treatments; and 4) public confidence that forest managers provide credible information regarding their fire and fuel management activities (e.g., Winter et al. 2002, Shindler and Toman 2003, Shindler et al. 2009, Toman et al. 2011).

Fire and fuels managers in the northern Lake States region must therefore balance competing demands as they seek to achieve multiple objectives including hazard reduction, ecosystem restoration, wildlife management, commodity production, and provision of recreation opportunities. In some cases these objectives may be complementary (e.g., fuels treatments may

provide improved habitat conditions) while in others they may involve difficult tradeoffs (e.g., the public may prefer thinning treatments due to perceived risks to private property).

This project was developed in response to a 2009 Announcement for Proposals by the Joint Fire Science Program to synthesize existing information and develop a comprehensive guide to fuels treatment practices in a format that is useful to land managers. Findings have substantial practical implications and can help improve the processes used to develop fuel management plans. Specific objectives of this project included:

- Synthesize existing information on ecological, wildlife, social, and fuel treatment effectiveness.
- Complete an interactive workshop with practitioners to identify management objectives, treatment options, influencing factors, and measures of success.
- Integrate key findings from existing research and management needs to create a comprehensive guide and develop a decision-aiding tool.
- Conduct interactive meetings with managers to refine the support tools and build user capacity.

III. STUDY DESCRIPTION AND LOCATION

The forests of the northern Lake States occur within the Laurentian Mixed Forest Province (McNab et al. 2007). This region is dominated by a variety of ecosystem types that are characterized as fire-dependent including jack pine forest ecosystem types; upland mixed-pine forest ecosystem types dominated by red pine and eastern white pine (*P. strobus* L.); mixed-pine and oak (*Quercus*) forest ecosystem types; and peatland forest ecosystem types dominated by black spruce (*Picea mariana* (Mill.) Britton, Sterns & Poggenb.), tamarack (*Larix laricina* (Du Roi) K. Koch), and other woody plant species. This project is focused on mixed red and white pine dominated forests.

As noted above, several governmental and nongovernmental organizations have responsibility for management of mixed-pine forests within the region. The federal agencies with the largest ownership are the USFS and USFWS. The NPS, USDI Bureau of Indian Affairs (BIA), and Department of Defense (DOD) have smaller, but still significant ownership within the region. Michigan, Wisconsin, and Minnesota Departments of Natural Resources also manage extensive areas dominated fire-dependent forests. Finally, tribal nations and non-governmental organizations including TNC and other land trusts manage fire dependent forests within the study region.

Wildfire issues in the United States are generally perceived to be primarily important in western or southern states. However, recent fire years have resulted in significant impacts within the study region. Between January 2002 and March 2011, Michigan, Minnesota, and Wisconsin experienced a combined 35,773 wildfires that burned 669,167 acres (NIFC 2011). Minnesota in particular has experienced some substantial fire activity in recent years. As this report was being completed, the Pagami Creek fire had burned more than 90,000 acres on the Superior National Forest resulting in the evacuation of several recreation users from the Boundary Waters Canoe Area and residents of nearby properties. In 2006, Minnesota also experienced the Cavity Lake Fire (burned 31,830 acres) and the Ham Lake Fire that burned more than 75,000 acres and

destroyed 130+ structures. Wisconsin's 2005 Cottonville Fire burned 3,400 acres and destroyed 30 residences. In Michigan, recent large fires include the Meridian Boundary Fire, Hughes Lake Fire, Sleeper Lake and Stonington Fires. Three earlier fires still have a strong influence on citizen confidence and support of manager-ignited prescribed burns in Michigan (Winter et al. 2002). In 1976 the Seney Fire ignited from a lightning strike burned 78,000 acres and required over 1,200 individuals to contain at a cost over \$12 million. In 1980, a Forest Service prescribed burn escaped and became the Mack Lake Fire that eventually burned 24,000 acres and 44 structures. This event was followed by a third fire in 1990, the Stephen Bridge Road Fire, that burned 6,000 acres of public and private land and destroyed 76 homes in a single day. Although these events occurred over a decade ago, citizen memories of them are still strong and they still influence manager and citizen perceptions of fire management and prescribed fire use (Winter et al. 2002). Forest conditions within the region suggest there is an increasing risk of major wildfires (Cardille and Ventura 2001, Haight et al. 2004). Many stands are vulnerable as a result of insect outbreaks, blowdowns, over-mature trees, and/or high stand densities (Miles et al. 2004, Hansen and Brand 2006, Perry 2006).

In some ways, the fire management problem in these forests can be as challenging as in western or southern forests due to the complex ownership patterns and lack of contiguous land areas in agency ownership. Public lands in the region are generally highly fragmented where federal or state-owned parcels are intermixed with private property and rural neighborhoods. Thus, agency fuel reduction activities are virtually assured of taking place in the public eye, creating a complex dynamic for how the fire management problem is understood, what values are most at risk, and citizen support for fuels treatments. In addition, such conditions mean that wildfires do not have to be very large or travel very far before directly impacting human developments. A recent review found that nearly all forests in the region are located within 25 km of densely populated communities (Radeloff et al. 2005).

Compared to other regions of the U.S., fire and fuels management programs within the Lake States are in an early stage of development. As an example, some National Forests within the region hired their first fuels planning personnel in the early 2000s. This is not to say the region lacks fire and fuels capacity as there are several individuals and organizations with substantial experience and knowledge; however, the networks to share information between these individuals, to develop and test new information, and to plan and implement large-scale fuels management programs are less well developed than in other regions of the U.S.

This project was designed to address those needs through two primary approaches. First, we brought together an interdisciplinary research team with experience in the region to review and synthesize the available and relevant literature in silviculture, forest ecology, wildlife ecology, forest economics, public acceptance, and decision science. Second, we worked directly with practitioners from across the region to better understand their decision-making environment, their goals and objectives, and recognized gaps in the currently available information. We used the following stages to accomplish these activities:

Stage 1: Each member of the research team completed a review of the applicable literature in his/her specific area of expertise. Following this review, the team developed a synthesis of existing research, summarized key findings, and identified management implications. Findings

were used to inform content for the interactive webinar described in Stage 2 below and to complete the comprehensive fuels guide.

Stage 2: A key part of the project design was direct interaction with managers and scientists from resource management agencies. Previous research in the study area (JFSP project 05-2-1-86) resulted in an initial characterization of manager objectives and potential alternative techniques for fuels treatment activities. For this project, we built on these existing findings following established structured decision-making protocols (Hammond et al. 1999) to gain a better understanding of the decision-making context, management objectives, and the factors that are considered when selecting fuels management techniques. We hosted an interactive webinar in May 2010 with participants from the USFS, USFWS, NPS, BIA, MI DNR, MN DNR, WI DNR, and TNC. While we had originally planned to host an in-person workshop, we elected to host a webinar due to travel constraints facing agency personnel. The webinar approach proved a useful means to engage participants from across the Lake States region and contributed to greater participation than would have been achieved through one in-person meeting.

Stage 3: Following the first workshop, the research team integrated findings from Stages 1 and 2 to develop the comprehensive fuels guide and a draft decision-aiding tool. The fuels guide is based on the synthesis of the primary literature completed in Stage 1 as well as the review and feedback from managers in Stage 2 to ensure relevance within the study region. The decision-aiding tool used findings from the first two project stages to outline and describe agency management objectives and alternative techniques to achieve those objectives. The decision-aiding tool is designed to help managers align their primary objectives for any particular fuels management project with the management technique or techniques most likely to be successful at achieving their objective. Based on the literature and interactions with managers, the tool is meant to compare the effectiveness of different techniques in achieving a particular objective.

Stage 4: In the final stage of the project, we convened a series of interactive meetings (both in person and web-based) with practitioners throughout the region. Many of these practitioners had participated in our previous webinar. In these meetings, we worked through the decision scenarios and alternative treatment techniques with practitioners to refine the quality (e.g., addresses real-world challenges) and the accessibility (e.g., user-friendly) of the decision-aiding tool. Moreover, by further describing the development and use of the decision-aiding process, these meetings contributed to building the capacity of participants to apply the final decision-aiding tool. The goal of these interactions was to facilitate direct interaction with practitioners, the end consumers of the proposed products, to ensure the tools meet their needs, and to facilitate improved decision-making. The decision-aiding tool was finalized following this final series of meetings.

IV. KEY FINDINGS

This project was not designed to conduct primary research. As such, the project did not result in traditional scientific findings. However, our review of the literature and interactions with managers did result in the following observations:

- **Limited empirical research has been completed on the application of fuels treatments in mixed-pine forests in the Lake States Region.** The review of prior research identified a limited number of studies related to fuels and fuel treatments within the region, dating as far back as the 1950s. More recently, limited research on fuel treatments has been published, and only general information is available in management guides for red pine and the other dominant tree species. Our review also discovered little information on fuel treatments from other regions that have similar forest ecosystem types (e.g., portions of the northeastern U.S.). While not directly focused on fuels treatments, a number of studies focused on using natural disturbance to guide forest management (an ‘ecological forestry’ approach) and forest ecosystem restoration have been initiated in recent years that provide additional insight into fuels treatments. While results from these projects provide useful information to fuels management, more research is needed with a direct emphasis on fuel reduction activities. With this in mind, we have shared these results with the members of the Lake States Fire Science Consortium (JFSP Project 09-4-11) and are working with the LSFSC to identify potential on-the-ground fuel treatment demonstration sites.
- **Public understanding and attitudes toward fire within the region are less mature than other regions of the U.S.** Given the ownership patterns in the Lake States, nearly all fuels treatments are conducted in the public eye. Accordingly, public understanding and acceptance are some of the primary challenges facing managers who are seeking to build programs. Recent research suggests residents of the Lake States are less likely to understand the rationale for fuels treatments and have lower levels of acceptance for these treatments than residents in other regions of the country (Shindler et al. 2009). However, this same research also provides some positive news. Of the three states in our region, residents in Minnesota were more likely to understand and support the use of fuel treatments. Minnesota is also the state with the most active and longest history of an active fuels reduction program. With appropriate planning and outreach efforts, practitioners in Wisconsin and Michigan may also be able to build similar levels of acceptance as agencies build their fire and fuels management programs.
- **Practitioners within the region are supportive of efforts to foster further interactions between managers from different organizations and with scientists.** In our interactions with managers, nearly all expressed interest in developing continued interactions with other managers as well as scientists from across the region. Managers expressed interest in learning from one another as well as contributing to and learning from scientific research. Our interactions described here are a subset of our larger efforts to develop a network of managers and scientists from across the region through the Lake States Fire Science Consortium (JFSP Project 09-4-11), one of the JFSP Knowledge Exchange Consortia. Managers and scientists across the region expressed considerable enthusiasm for the development of such a network and indicated a belief that it would contribute to more effective decision making within the region.

V. MANAGEMENT IMPLICATIONS

- **Capitalize on practitioner experience and expertise:** While research on fuels treatments within the region is limited, practitioners have a substantial amount of practical experience that has not yet been fully captured. Developing and maintaining relationships between

organizations can help facilitate information sharing and knowledge building between organizations. In addition, through such relationships, the research community will be able to identify knowledge gaps that can be addressed through research programs. The Lakes States Fire Science Consortium is working to document existing practitioner experience and expertise and make this information available to a larger group of resource managers across the region.

- **Decision-aiding activities and tools offer important support to agency managers:** While several practitioners have considerable fuels reduction experience within the region, many programs have grown in recent years resulting in the addition of new personnel. Moreover, as agency management goals continue to evolve all fuels managers have to balance the reduction of forest fuels with other management objectives. Decision-aiding tools can help managers examine the performance of the range of alternative management approaches in achieving their goals. Developing additional and more detailed decision support activities will be important as managers make decisions about how best to allocate their resources.
- **Emphasize the development of public awareness and support:** Given the controversy surrounding most federal resource management decisions, agency personnel can feel that there is little public support for or understanding of management actions. However, citizens in each location recognize the need for fuels reduction and have expressed at least some support for agency fuels programs. The job of developing public acceptance of fire management programs is a continuing process rather than an end product. Managers should recognize the importance of public support to the long-term success of their fuels management programs. Substantial research has demonstrated that public acceptance of fuel treatments increases when the public: understands the rationale behind treatments, has a good sense of likely outcomes from fuels treatment practices, has confidence in the ability of managers to effectively implement treatments, and has adequate opportunities to participate in the project planning process.

VI. RELATIONSHIP TO OTHER RECENT FINDINGS AND ONGOING WORK

Members of the research team are involved in a number of ongoing efforts that are linked to this project, including:

- **Lake States Fire Science Consortium (JFSP Project 09-4-11):** The mission of the Lake States Fire Science Consortium is to accelerate the awareness, understanding, and adoption of wildland fire science information by federal, tribal, state, local, and private stakeholders across the Lake States from Minnesota to New York, and the adjacent Canadian provinces of Ontario and Manitoba. Our vision is to provide the "best available" information on fire and fuels for a variety of audiences. The Consortium aims to link managers, scientists, policymakers, and disciplines by providing information and tools to support management of fire-dependent ecosystems in the Lake States region
- **Social Science at the Wildland Urban Interface: Creating Fire-Safe Communities (JFSP Project 07-1-6-12).** This project, which is slated for completion soon, is designed to summarize and prioritize current knowledge related to the social issues of fire management

and develop effective tech transfer methods to communicate findings that can be understood and implemented by local agencies and citizen groups. The first phase of this research brought prominent social scientists together for a workshop to examine the body of social science research and to suggest which questions merit further investigation. Subsequent phases included a synthesis of existing social science findings and production of a digital video production and implementation field guide featuring management personnel and citizen groups that have had success developing fuels reduction programs.

- **Examining the influence and effectiveness of communication programs and community partnerships on public perceptions of smoke management: A multi-region analysis (JFSP Project 10-1-03-7).** This project examines how communication programs and fire and fuels-related community partnerships influence public perceptions of smoke management across multiple regions. Using a case study design, this project will compare communities where smoke (from wildfire or prescribed fire) has impacted citizens and examine the factors that influence acceptance levels. We will identify communication strategies that were used in relation to smoke, assess community preparedness for fire and presence of partnerships, and explore whether these strategies and partnerships influence citizen tolerance of smoke. Preliminary results will be synthesized and used in a series of behavioral experiments at each study site to assess the influence of different interventions on participants' attitudes and behaviors towards smoke.
- **Integrating Fuels Reduction and Pine Barrens Restoration In Endangered Kirtland's Warbler Habitat Management (JFSP Project 10-1-06-21).** To address the needs to provide habitat for Kirtland's warbler while reducing the risk of fire and providing for rarer habitat types, this project will quantify the pre-European distribution, abundance, and spatial patterns of young jack pine and jack pine barren ecosystems and integrate these findings into the restoration of barrens and the placement of fuel breaks. Providing a broad, spatial framework of these patterns across ownerships will provide guidance for future habitat management actions.
- **Understanding the Role of Risk Perception and Risk Attitudes in Shaping Public Response During a Wildfire (ongoing project funded by the USFS Northern Research Station).** The primary objective of the study is to identify how risk perception (i.e., degree of holistic concern and expectation of personal impact of fire) and risk attitudes (i.e., different levels of risk tolerance/aversion in multiple decision relevant domains) influence planned response of homeowners during a wildfire. Specifically, this study will seek to improve understanding of the following areas: 1) the role of risk perception and individual risk attitudes in shaping individual response during a wildfire and why some individuals may choose to ignore evacuation orders; 2) the relative role of risk attitudes to other issues of concern in shaping public response to a wildfire; and 3) how to best communicate about wildfire risk based on specific perceptions and attitudes found among particular demographics.
- **Assessing the Impact of Positive and Negative Outcomes on the Acceptability of Wildfire Management Strategies Among USFS Personnel (recently completed project funded by the USFS PSW Research Station).** This project examined the prevalence of risk-

based biases among fire managers when choosing how to respond to a wildfire event. The results indicate that such biases (including discounting of long-term consequences, loss aversion and a tendency to maintain the status quo) have the potential to influence wildfire management. However, individual attitudes toward risk or an agency culture of risk aversion may counterbalance such heuristics, whereas increased experience may lead to overconfident intuitive judgments and a failure to incorporate new and relevant information (Wilson et al. 2010). These results point to a need for context-specific decision support tools that protect against common biases that result from scientific uncertainty and conflicting management objectives.

VII. FUTURE WORK NEEDED

Additional research is needed in the following topic areas:

- **Fuel treatments:** The fact that there is little information available from direct field investigations related to fuel treatments in mixed-pine forest ecosystem of the northern Lake States is evidence that additional research is needed. Both replicated field experiments and demonstration sites of fuel treatment methods are needed. Based upon the results of this project, as well as other JFSP-funded research from the region, we would suggest that these fuel treatment studies focus on the role of how fuel treatments can help meet not only fuel management objectives, but other management objectives (e.g., habitat management) as well.
- **Decision support:** Additional research is needed into ways to improve the integration of scientific information into management decision-making within the region. One specific future project would be to further refine the initial decision-aiding tool developed in this project by developing specific likelihood estimates of consequences for each potential treatment technique on the range of management objectives. This would result in development of a customizable decision-aiding tool that would allow managers to better evaluate the outcomes of potential treatments on the range of objectives of greatest importance to their organization. This project is able to specify the general direction of performance (positive, negative, neutral) for each management strategy, but the data does not exist to be more specific without further research and extensive expert elicitation. Further work could also expand this tool to other ecosystem types within the region. Related research could examine the effect of ongoing efforts to develop a network of scientists and decision-makers on the integration of science in management decisions and of management concerns in research projects.
- **Public acceptance:** Public acceptance is one of the key variables influencing adoption of fuels management programs. While much has been learned about public acceptance, work is still needed to: examine the temporal changes in acceptance within the Lake States with increased prevalence of fuels management programs, better understand the factors that influence citizen trust and confidence in fire and fuel managers (particularly relevant in this region due to lasting influences of the escaped Mack Lake fire), examine the factors that influence adoption and maintenance of risk reduction activities on private lands, and integrate findings across the stages of fire event (pre-, during, and post-fire).

VIII. DELIVERABLES CROSSWALK (based on deliverables promised in proposal)

Deliverable	Description	Status
Project website	Deliverables available through the Lake States Fire Science Consortium website (http://lakestatesfiresci.net/) and through the JFSP website (www.firescience.gov)	Updated as products are completed
Initial synthesis of available research	An initial summary of existing research	Completed
Interactive workshop	Hosted webinar in Spring 2010 with participants from USFS, USFWS, NPS, BIA, MI DNR, MN DNR, WI DNR, and TNC; additional in-person meetings were held in Autumn 2011	Completed
Decision aiding tool	Decision-aiding tool allows managers to examine the effectiveness of different treatments on accomplishing their objectives	Initial version completed Updated version in final stages of development and will be posted on the project website when complete.
Description of development and use of tool	User guide for decision-aiding tool, with example scenarios, and accompanying video.	Descriptions of initial tool available through project website. Final user guide when tool complete to be published as a Lake States Fire Science Consortium Technical Guide. Video is in production and will be posted to the project website.
Fuels Guide	Synthesis of existing research on fuels management within mixed red and white pine forests in the northern Lake States	In production as a USFS General Technical Report through the Northern Research Station
Progress reports	Description of progress towards objectives, timeline of project, findings to date	Completed annually
Final report	Summary of project, key findings, management implications, and future research needs	Completed

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